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ABSTRACT

A continuing and vexing problem associated with survey instrument development is the creation of items, initially, that correlate favorably a posteriori with constructs being measured. This study tests the use of symbolic-logic matrices developed by D. G. Coleman (1979) in creating factorially "pure" statistically discrete constructs in survey instrument design. The study used symbolic-logic (verbal logic) "truth tables" to increase statistical factor loadings in confirmatory factor analysis studies and to develop discrete constructs. Initial experimental work with truth tables increased, hypothetically, construct purity in construct validation. Construct validation helps to assure that items created for measuring specific theoretical or real constructs do, indeed, represent the distinct qualities measured. In November 1996, the National Association of Elementary School Principals (NAESP) approved the revision of the Administrative Diagnostic Inventory (ADI), the title given to the diagnostic procedure conducted within their assessment center. To assist the NAESP in the use of the ADI for the assessment of current and prospective school principals, this study evaluated the construct validity of the instrument with 203 teachers enrolled in educational administration programs. Results show the improved content validity and construct validity of the revised ADI. Factor analysis shows that the descriptors within the skill dimensions are highly correlated and are significant measures of the constructs for which they were written. (Contains 2 tables and 20 references.) (SLD)

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Using Symbolic-Logic Matrices to Improve Confirmatory Factor Analysis Techniques

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Abstract

A continuing and vexing problem associated with survey instrument development is the creation of items, initially, that correlate favorably *a posteriori* with constructs being measured. The purpose of the study tests the use of symbolic-logic matrices developed by Coleman (1979) in creating factorily "pure" statistically discrete constructs in survey instrument design.

The study used symbolic-logic (verbal logic) "truth tables" to increase statistical factor loadings in confirmatory factor analysis studies and to develop discrete constructs. Initial experimental work with truth tables increased, hypothetically, construct purity in construct validation. Construct validation helps to assure that items created for measuring specific theoretical or real constructs do, indeed, represent the distinct qualities measured.

In November 1996, the National Association of Elementary School Principals (NAESP) approved the revision of the Administrative Diagnostic Inventory (ADI), the title given to the diagnostic procedure conducted within their assessment center. To assist the NAESP in the use of the ADI for the assessment of current and prospective school principals, this study evaluated the construct validity of the instrument.

USING SYMBOLIC MATRICES TO IMPROVE CONFIRMATORY FACTOR ANALYSIS TECHNIQUES

INTRODUCTION

The purpose of the study was to validate the constructs of the revised Administrative Diagnostic Inventory (ADI), since no validation studies existed. The validation was necessary to assure that scores achieved on individual items (descriptors) within each construct correlate favorably with one another on the 13 constructs and that the newly re-designed constructs maintain individual identities. The ultimate goal of the study was to "confirm" the discreteness of the 13 behavioral constructs first identified and the intercorrelation of the eight descriptors identified within each construct. In other words, the study sought to determine whether the 13 constructs measure separate and distinct characteristics of effective school principals and whether the eight descriptors developed for each construct are intercorrelated and measure specific constructs.

Data for the study originated from a paper and pencil instrument administered to teachers and entry level administrators who evaluated their supervising principal. The protocol used in the construct validity required subjecting these survey data to confirmatory factor analysis, using R factor analysis with Kaiser normalization and Oblimin rotation.

With the commitment of the National Association of Elementary School Principals (NAESP) to use the ADI for the assessment of current and prospective principals, construct validity is crucial and essential. The results of the study will assist the NAESP and assessment centers across the country with the goal of using valid measures to assess educational administrators.

THEORY/RATIONALE

Research indicates that the school principal is recognized as a significant factor in school success. The quality of teaching and student learning, the school climate, and the confidence in public schools are directly related to the performance of school principals (Lipman, 1981; Smith & Andrews, 1989). The importance of school principals necessitates a need for effective ways to evaluate and assess school administrators. The field's conceptualization of organizational processes, including the leadership construct, is constantly evolving (Glasman & Heck, 1992; Hallinger, 1992; Leithwood & Hallinger, 1993). The assessment of leadership and management skills and abilities is now recognized as a potential tool in the preparation, development, selection, and professional growth of school principals (Edmonds, 1982).

One method for identifying and measuring administrative potential is the assessment center, a model created with simulations and exercises to assess skills and behaviors of individuals (Elsaesser, 1990). The field of education developed performance assessment systems to address the heightened concerns for schooling and for finding good administrators (Sirotnik & Durden, 1996). The creation of the ADI was in response to the demands for principal effectiveness substantiated by stringent accountability measures.

Showing the relationship between variables and constructs represents a very important part of the content of any scientific field (Comrey, 1973). In some fields, such as education, less agreement exists among researchers concerning what variables relate to each other. The relationships between variables are often not clearly defined. Factor analysis represents a growing body of statistical methods that can be of great value in these areas (Hair, 1979). Factor

analytic methods help educational researchers to define their variables and relate them to each other in an attempt to develop their science to a higher level.

A research and writing team of eight professional educators addressed the content validity of the revised ADI in late 1995 and early 1996 (Coleman & Creighton, 1996). By verifying the construct validity of the instrument, districts will gain in planning relevant and productive staff development for school principals. In addition, educational leadership institutions can improve the development of administrative training programs.

The purpose of the study was to use confirmatory factoring procedures to conduct a construct validation of the ADI. The research questions derived from the rationale and used to focus the study were:

1. Are the eight descriptors within each of the 13 constructs intercorrelated and truly measuring the specific construct?

2. Are the 13 constructs on the ADI discrete and separate measures of effective elementary school principals?

NEED FOR ADI REVISION

Validity studies of the ADI (Dale, 1988; Menrad, 1990; Elsaesser, 1990; James, 1991; Durden, 1994; Sirotnik & Durden, 1996) emphasized a need for construct validation. Though research indicated limited data on various elements of the ADI in dissertations, no construct validation studies were completed (Coleman, 1995).

California State University Fresno (CSUF) was the first franchise signed by the National Association of Elementary School Principals (NAESP) to use the ADI after the rights had been

purchased from the University of Washington. By October 1995, CSUF had conducted 13 assessments covering approximately 150 candidates (Coleman, 1995).

From the beginning, the validity and reliability of the ADI was questioned. Though the ADI was believed to have been created around sound educational theory, and by a wide variety of educational experts and practitioners, research from the field raised concerns regarding construct validity.

In November 1995, Coleman prepared a report to the NAESP detailing three construct validation studies. The first one by Petrulis (1994) and the other by Coleman (1994) produced similar results: constructs were very difficult to decipher.

The third study (Coleman, 1995) subjected each of the 12 constructs to individual construct validity measures with equally disappointing results. Thirty-seven constructs were found instead of the purported 12 on the ADI instrument. Descriptors failed to load on the appropriate constructs and little variance was accounted for by the first six factors (31.9%). The evidence supported revising the ADI and completing additional studies of the instrument authenticating its validity.

A major concern pertained to evidence that the definition stems used in defining the constructs appeared as multiple rather than singular measures. Each of the constructs therefore, displayed a variety of phrases supposedly describing one specific construct. This resulted in the construct measuring several rather than a single variable (Coleman, 1995). If multiple stems are used, as in the case of the ADI, the data may sort into multiple factors on a single construct as indicated by many factors showing up in a factor analysis.

The Coleman study indicated that the content validity of the ADI was not a major problem, but indicated that the constructs did not necessarily measure the whole range of principal effectiveness variables. Some of the constructs were not mentioned in contemporary literature as significant in principal effectiveness and others appeared to overlap each other.

In discussing the earlier ADI, Sirotnik and Durden (1996) pointed to the issue of construct validity and suggested that the 12 ADI dimensions did not appear to be independent measures of leadership as presently defined and operationalized. They contended that the faulty dimensions may be improved by including more involvement from other educator groups (such as teachers and school-based administrators) in the refinement and development of the ADI. Durden's recent research on the ADI (1994) had emphasized the importance of regular and constant evaluation and revision of assessment center models of performance evaluation:

> Leadership expectations are changing. Analysis of assessment centers should be regular and updated periodically, every four years or so. This is another reason for further research of the ADI and NASSP systems, since the original job analysis was conducted more than five years ago. (p. 252)

FACTOR ANALYSIS

The use of factor analysis to provide construct validation is not new. In *Educational and Psychological Measurement*, Guilford (1946) stated:

> The factorial validity of a test is given by its loadings in meaningful, common, reference factors. This is the kind of validity that is really meant when the question is asked "Does this test measure what it is supposed to measure?" (pp. 437-438)

Factor analysis is used in this study to check for discreteness among constructs and intercorrelations among items used in measurement. The validation procedure provides additional assurance that what is being measured is valid.

Factor analysis has two primary functions in data analysis (Nunnally, 1978). One function is to identify underlying constructs in the data. As an example, the analysis may show the variables of "seeks clarity in purpose" and "involves stakeholders in the planning process" to actually be indicators of the same theoretical construct (e.g., planning). A second role of factor analysis is simply to reduce the number of variables to a more manageable set.

In reducing the number of variables, factor analysis procedures attempt to retain as much information as possible and to make the remaining variables as meaningful and as easy to work with as possible. The general purpose of factor analytic techniques is to condense the information contained in a number of original variables into a smaller set of composite factors, with minimum loss of information.

METHODOLOGY

In November 1995, the National Association of Elementary School Principals (NAESP) decided to revise the ADI assessment instrument. Education administration professors from five universities, practicing school superintendents and principals, research consultants, assessment center directors, and representatives from NAESP began the process immediately, completing the new instrument in February 1996 (Creighton, 1996).

Step 1

The initial assignment of the writing and research team was to identify constructs believed important to school administrators. The team began by researching constructs and descriptors used by other organizations, various national accreditation agencies, task forces, and other assessment instruments. Previous ADI assessment instruments, National Association of Seconday School Principals (NASSP) assessment dimensions, National Council for the Accreditation of Teacher Education (NCATE) standards, National Policy Board for Educational Administration (NPBEA) competencies, and a literature review were studied. The purpose of examining various recommended competencies was to identify and select the most appropriate and applicable constructs to be used for the ADI.

The writing team analyzed the existing models of proficiencies, standards, domains, and dimensions to form appropriate constructs for the ADI. The team first examined existing constructs individually, and then collectively, to determine those believed to be most important. The result was an agreement on 13 constructs (dimensions), or knowledge and skills of effective school leaders. These skills covered both management (personal skills) and leadership (inter-personal) skills. The constructs are listed in Figure 1, along with the 12 original ADI constructs for comparison.

Step 2

The next step was to define the newly identified constructs. The writing team studied previously written definitions from the competency and standards documents. The team maintained that many of the original definitions were too broad and contained several stems that would cause overlap with other constructs and definitions, resulting in weak validity and

reliability. The creation of single stem definitions resulted in more clear and concise definitions. An example is provided in Figure 2, comparing two definitions for creativity and identifying multiple vs single stem definitions. Previous research (Andrews, 1965; Brubaker, 1983; Coleman, 1995) indicates that content validity is decreased with such multiple stem constructs.

REVISIED ADI	PREVIOUS ADI
1. Planning	Problem Analysis
2. Organizing	Judgement
3. Problem Solving	Organization Ability
4. Decisiveness	Decisiveness
5. Creativity	Group Leadership
6. Systems Analysis	Instructional Leadership
7. Vision	Creativity
8. Communications	Oral Communications
9. Instructional Leadership	Written Communication
10. Group Leadership/Team Building	Human Relations
11. Climate Development	Resourcefulness
12. Moral Responsibility	Educational Values
13. Instructional Analysis	

FIGURE 1
ADI Construct Comparison

CREATIVITY (original ADI)

Generates and recognizes innovative solutions in work-related situations; exhibits openness to new ideas from others; demonstrates originality in developing policies and procedures; performs under pressure and during opposition; thinks well during oral interchange; maintains effectiveness in varying environments with various tasks, responsibilities, and people; exhibits behavior flexibility; adjusts time schedule as need arises; and has tolerance for ambiguity.

CREATIVITY (revised ADI)

Demonstrates innovation and inventiveness in work-related situations.

FIGURE 2
Multiple vs Single Stem Definitions

Step 3

After reaching agreement on 13 construct definitions, the team members individually wrote "descriptors" that would provide differing measures for each construct. When finished, they reviewed the list to select the most relevant. The task was complex and required a great deal of reworking the items. As an example, the team agreed upon a descriptor for creativity: *open and receptive to nontraditional sources of information.* After considerable debate and discussion, a team member asked how "open and receptive" could be observed in principal behavior? The team agreed with the concern and rewrote the descriptor to read: *demonstrates openness and receptivity to nontraditional sources of information.*. The team agreed that, under certain circumstances, the act of demonstrating openness and receptivity could be observed in the behavior of a principal. The issue for the team was to select descriptors that were specific, interrelated with each other, and measured the construct.

Step 4

To improve the inner-item correlations and the construct validity of the constructs, the team used symbolic-logic matrices to verify that each descriptor logically agrees with others measuring the same construct. A symbolic-logic matrix resembles a correlation matrix but allows individual items to be compared according to verbal construction (logic) by subjecting them to "if/then" statements (Coleman, 1993 and 1995).

When using symbolic-logic matrices to compare dimensions or constructs, two-way disagreements are desired since constructs should be discrete and measure different behaviors. Figure 3 demonstrates "if/then" statements for instructional leadership and creativity. If the two constructs are truly discrete and separate measures of effective school leadership, the "if/then" statements should disagree logically. The disagreement should produce a two-way disagreement, which means the reversed "if/then" statement should also result in a "no, or not necessarily." A principal who works effectively with the school community for example, does not necessarily demonstrate innovation and inventiveness. Reversing the statement also results in a negative consequence. The symbolic-logic matrix can be used to identify discreteness and to help assure differences between constructs.

Figure 4 illustrates a symbolic-logic matrix with the construct created for instructional analysis and the eight matching descriptors. When using the matrix to strengthen correlation between descriptors, two-way agreements are desired. Two-way agreement best predicts high inter-item correlation. The intent of using the matrices was to refine and tighten the constructs and descriptors on the ADI.

INSTRUCTIONAL LEADERSHIP
works effectively with the school community to advance student learning.

CREATIVITY
demonstrates innovation and inventiveness in work-related situations.

If/then statements:

1. If a principal works effectively with the school community to advance student learning, then he/she demonstrates innovation and inventiveness in work-related situations.

2. If a principal demonstrates innovation and inventiveness in work-related situations, then he/she works effectively with the school community to advance student learning.

FIGURE 3
Creating a Symbolic-Logic Matrix with Two ADI Constructs

Pointing out a distinction between *two-way agreements* and *two-way disagreements* may help clarify the appropriate use of the symbolic-logic matrices. In using the matrices to improve the intercorrelation of items, as in the case of the ADI descriptors, two-way agreements are desired. Two-way agreement between and among items across the entire matrix measuring a single construct should reflect reasonably high inter-item correlation. However, when the desire is to maintain discreteness, as in the case of the ADI constructs, two-way disagreements are necessary. To retain discrete constructs in a multi-construct design, care must be maintained to create constructs that are independent of each other and possessing items reflecting low levels of statistical correlation with items from other constructs (Coleman, 1996). The symbolic-logic matrices should reflect two-way disagreement among the constructs when low level of inter-item correlation is desired.

INSTRUCTIONAL ANALYSIS: works effectively with teachers to improve instruction.

Variables	1	2	3	4	5	6	7	8
1. encourages instructional improvement	XX	A	A	.	A	A	A	A
2. provides suggestions helpful to teachers for improving instruction	A	XX	A	.R	A	.R	A	A
3. possesses high expectation for student improvement	A	.	XX	A	A	A	A	A
4. demonstrates interest in student intellectual growth and development	.	.R	.	XX	A	.	A	A
5. emphasizes student achievement	A	.	A	A	XX	A	A	A
6. demonstrates expertise in analyzing teaching and learning	A	.R	A	A	A	XX	A	A
7. maintains expertise of alternative instructional practices	A	.	A	A	A	A	XX	A
8. possesses knowledge of activities occurring in various classrooms	A	.	A	A	A	A	A	XX

FIGURE 4
Completed Symbolic-Logic Matrix with ADI Construct and Descriptors

Note.

The numbers across the top of the matrix represent the eight descriptors, and the "XX" are placed in the cell where the descriptor correlates with itself. Obviously, the descriptor correlated with itself would result in a 1.00 correlation. The purpose of this process is to verbally correlate the descriptors with each other and the construct.

Starting with a correlation between descriptor 1 and descriptor 2 (second cell across the first row), an "if/then" statement is created to read, "if a principal encourages instructional improvement (descriptor 1), then he/she provides suggestions helpful to teachers for improving instruction (descriptor 2)." If the statement is agreed to, an "A" is placed in the cell representing agreement. If the statement is not agreed to, a "dot" is placed in the cell representing one-way disagreement. The evaluator moves on to the third cell across the first row, until each item serves as the consequence to the original item serving as the antecedent.

As the evaluator begins to address the columns, a need exists to reverse the "if/then" statement. For instance, 1 across correlated with 2 down is the reverse "if/then" statement as 2 across correlated with 1 down. If a two-way disagreement is encountered, an "R" (rejection) is placed in the cell. A "dot" indicates one-way disagreement; an "R" indicates two-way disagreement; and an "A" represents two-way agreement.

A two-way agreement has the best chance of having high inter-item correlation. A one-way agreement drops the probability of a high correlation coefficient while two-way rejection drops the coefficient even further. Descriptors which have two-way disagreements recorded (R), are considered poor and either reworked or discarded.

DATA COLLECTION: SURVEY/QUESTIONNAIRE

A paper and pencil survey instrument with the 104 ADI descriptors provided for collecting information on practicing school administrators and for verifying the construct validity of the ADI. The intent was to further purify the descriptors and constructs and collect data essential for use in a field-based version of the ADI. Eight items were created for each construct to provide for selecting at least six highly inter-correlated items. Methodically placing the 104 descriptors throughout the survey prevented the respondents from recognizing any of the 13 individual constructs. The intent was to provide each respondent the opportunity to answer each item independently while minimizing bias or preconceived notions. Survey respondents rated their current administrator with the 104 descriptors on a 6-point Likert scale. Testing the relationships between descriptors and among constructs was one of the purposes of the survey.

Two-hundred-three teachers enrolled in the educational administration programs at California State University Fresno, and teachers and vice-principals in the California School Leadership Academy completed the survey during February and March 1996. Formatting the responses on diskette with Microsoft Excel 4.0 allowed for the transfer of data to the Statistical Package for the Social Sciences (SPSS v6.1). The study subjected the data to R factor analysis with Kaiser normalization and Oblimin rotation. By subjecting the data from the 203 survey respondents to factor analysis, the intent was to confirm the correlations between individual constructs and descriptors, and to address the two research questions developed for study direction and focus.

The use of factor analysis had two functions in the study. The first was to identify underlying constructs in the data, the second, to reduce the number of variables to a more

manageable set. In reducing the number of variables, factor analysis procedures attempt to retain as much of the information as possible and to make the remaining variables as meaningful and as easy to work with as possible. The factor rotation scheme selected in the study was Oblimin oblique to maximize the interpretation of factor loadings.

FINDINGS AND INTERPRETATIONS

Addressing the first research question involved running a correlation matrix for each of the 13 constructs with the accompanying eight descriptors. Analyzing the resulting data determined the extent of correlation among descriptors and the degree to which the descriptors represented a single factor. Two or more factors representing the eight descriptors indicated more than one construct underlying the descriptors.

Correlation matrices for the 13 ADI constructs revealed strong intercorrelation among the items for 11 of the constructs. The correlation coefficients were well above the suggested significance level of .18, with most ranging from .60 to .80, indicating a high degree of correlation among descriptors. As an example, the ADI construct for creativity is shown in Table 1. The data reveal all coefficients above .18 and only one extracted factor possessing an eigenvalue of 5.47. Factor loadings for the descriptors ranged from .73 to .91. The analysis suggests the items are effective measures of the construct, and identify a single factor as predicted (Creighton, 1996). In addition, the eight descriptors for 11 of the constructs loaded on one specific factor (ranging from .70 to .90), further suggesting the items as clear measures of one skill dimension.

TABLE 1
Correlation Matrix - ADI Construct of CREATIVITY

	VO04	VO17	VO30	VO43	VO56	VO68	VO81	VO95
VO04	1.00							
VO17	.77	1.00						
VO30	.73	.69	1.00					
VO43	.66	.72	.68	1.00				
VO56	.77	.76	.73	.71	1.00			
VO68	.63	.67	.55	.59	.77	1.00		
VO81	.61	.50	.63	.53	.63	.52	1.00	
VO95	.50	.47	.47	.64	.60	.57	.66	1.00

Variable	Communality	Factor	Eigenvalue	Percent of Variance	Variable	Factor 1
VO04	.75	1	5.47	68.3	VO04	.86
VO17	.85	2	.73	9.1	VO17	.85
VO30	.83	3	.53	6.7	VO30	.83
VO43	.84	4	.44	5.5	VO43	.84
VO56	.91	5	.27	3.4	VO56	.91
VO68	.80	6	.21	2.7	VO68	.80
VO81	.76	7	.18	2.3	VO81	.76
VO95	.73	8	.16	2.1	VO95	.73

The communality tables further support the strength of the descriptors for the 11 constructs. The high communality coefficients indicate that the factor accounts for most of the variance. In other words, the descriptors for the construct have much in common.

A restatement of the first research question may be helpful: Are the eight descriptors for each of the 13 constructs intercorrelated and measuring the specified construct? The correlation matrices for the ADI constructs revealed the descriptors for 11 of them to be correlated from .47 to .96. These 11 constructs also loaded on a single factor each. Clearly, 11 of the 13 constructs are unidimensional.

Two constructs, *climate development* and *instructional analysis*, however, resulted in two factors identified by eigenvalues greater than 1.00. The rotated factor matrix for these two factors showed some variables loading highly on one factor and other variables loading highly on

the second factor. This splitting of the construct over two factors points to ambiguity in responses to the eight descriptors for each. In other words, the eight descriptors are not measuring a discrete construct.

Factor Analysis

The first step in addressing the second research question involved running an unrotated factor analysis, or principal components method, of the 104 descriptors (variables) to identify the sources of variance and factorial structure in the data. The result was the identification of 17 factors with eigenvalues of 1.0 and greater, four more than expected. Factors 18 through 104 are considered trivial and are not interpreted.

The 17 factor solution was subjected to Oblimin (oblique) rotation to improve the interpretation. The major option to the analyst in rotation is to choose between an orthogonal method or an oblique method. An oblique factor rotation is desirable because it is theoretically and empirically more realistic (Hair, Anderson, & Tatham, 1979).

The result was disappointing. Only six of the 13 ADI constructs loaded heavily on individual factors. The other seven constructs had so few descriptors clustering in groups that identifying or labeling them was difficult.

The majority of significant descriptors (.50 or greater) loaded on 6 factors. Four factors noticeably identified discrete constructs as written for the ADI. Factor 1 consisted of seven of the eight descriptors written for the ADI construct problem solving which implies a label or name for Factor 1 as problem solving. Factor 2 contains seven of the eight descriptors written for the construct of creativity. Factor 8 contains seven of the eight descriptors written for the construct

of communication, and Factor 12 contained six of the eight descriptors written for the construct of organization. Factors 4 and 6 appeared somewhat ambiguous, but upon careful analysis, both factors contained heavy loadings for descriptors written for instructional analysis and instructional leadership.

The descriptors for *climate development* and *instructional analysis* consisted of lower correlation coefficients, many correlating with descriptors for other constructs. The eight descriptors branched into separate areas, rather than measuring one discrete construct.

DISCUSSION

The use of symbolic-logic matrices by the ADI writing team resulted in the creation of 11 constructs with fairly strong measurement items. For what reasons do the symbolic-logic matrices not have the same result with the constructs of climate development and instructional analysis? What causes these two constructs to split into two different factors?

The two factors for climate development shown in Table 2 can be labeled (a) the psycho-socio environment of management and (b) the physical environment of management, reflecting the content of the descriptors. The one, maintains a facilitative psychological and social environment, implying attention to a psycho-socio detail. The other, attends to aspects of the physical environment, implying attention to physical details. The suggestion is not that the construct of climate development is an inappropriate construct for judging effective school administrators, but as written, is comprised of two distinct concepts. Two possible remedies exist: (a) rewrite the descriptors to load on one or the other or (b) create two separate constructs, thus adding a construct to the ADI instrument.

TABLE 2
Rotated Factor Matrix of ADI Construct Climate Development

Descriptor	Factor 1	Factor 2
VO11	.36	.61
VO24	.67	.09
VO37	**.11**	**.84**
VO50	.87	.08
VO63	.02	.72
VO76	**.96**	**.05**
VO89	.84	.06
V102	.39	.65

Descriptor VO37
attends to aspects of the physical environment to maximize learning.

Descriptor VO76
maintains a facilitative psychological and social environment.

The same difficulty marked instructional analysis, which also divided into two factors. These factors were labeled (a) emphasizing student achievement and (b) emphasizing teaching. This construct can be improved in the same manner as suggested for climate development.

RECOMMENDATIONS

A primary function of factor analysis is to reduce redundancy and ambiguity. The data analysis of the study clearly identifies the ADI constructs of climate development and instructional analysis as being indiscrete measures. These two dimensions are important skill dimensions of effective school leadership and should not be discarded as constructs. Again, the suggestion is not that these two constructs are inappropriate skill dimensions of effective school principals, but that the constructs as written contain two underlying constructs within one. Both

constructs can be improved by rewriting descriptors to load on one rather than two factors. This could be accomplished by eliminating ambiguous and conflicting wording.

Looking at the correlation matrix and communality table for each of the 13 ADI constructs, the data reveal 1 or 2 descriptors with lower coefficients. Several of these descriptors also failed to load on any of the identified 17 factors on the oblique rotated factor matrix. Repeating a factor analysis with a reduced number of descriptors (variables) is recommended. Eliminating the two lowest coefficients in each construct would reduce the variables from 104 to 78. The correlations between variables would likely improve and assist in further improving the construct validity of the ADI.

The ADI writing team was careful to subject the eight descriptors within each construct to the symbolic-logic matrix process. The team also utilized a 13 X 13 symbolic-logic matrix to test the 13 constructs for discreteness. The team failed however, to go further and create a 104 X 104 matrix to test the eight descriptors within each construct with the descriptors of other constructs for discreteness. In other words, testing the construct definitions for disagreement on the symbolic-logic matrix does not assure the descriptors within each construct to be discrete when compared to descriptors within other constructs.

The symbolic-logic matrix process which was so successful with the creation of descriptors within constructs can be of further help with the issue of construct correlations. The same process used for two-way agreement of descriptors can be equally valuable in seeking two-way disagreements. Though the constructs were worked through this process by the ADI writing team, the individual descriptors across constructs were not.

Subjecting the descriptors to a 104 X 104 symbolic-logic matrix is suggested for improving the discreteness of ADI constructs. Though the process would be difficult for one person, teams or groups could work through the process in a reasonable amount of time. If two-way disagreements could not be reached, individual descriptors would need to be reworded or modified in some way. Using a 104 X 104 matrix, descriptors within one construct can be compared with descriptors within another construct. For example, a descriptor within the construct of problem solving compared with a descriptor in the construct of planning needs to result in a two-way disagreement. Though the correlation between decriptors within each construct should be high, the correlations across constructs should be low.

An alternative recommendation for improving the discreteness of constructs involves the creation of a smaller and more manageable symbolic-logic matrix. The data suggest six of the 13 constructs to be appropriately discrete. The creation of a matrix for the remaining seven would concentrate only on the ones appearing weak. This procedure would require a smaller truth table of 56 X 56. Even smaller 8 X 8 symbolic-logic matrices could be created to match existing high correlations from the factor matrix. For example, a high correlation exists between Factor 1 (problem solving) and Factor 2 (creativity). Using an 8 X 8 matrix comparing the eight descriptors of problem solving with the eight descriptors of creativity would result in the tightening of construct discreteness.

SUMMARY

The revised Administrative Diagnostic Inventory (ADI) shows significant improvements in content validity and more specifically, construct validity of the instrument. Factor analysis

reveals the descriptors within each of the 13 skill dimensions (constructs) to be highly correlated and significant measures of the construct for which they were written.

Factor analysis also reveals six of the 13 constructs to be discrete and separate measures of effective behavior of school principals. The seven constructs which did not prove discrete can likely be improved by subjecting the 104 descriptors to the verbal logic of symbolic matrices.

Even though the ADI contains some weaknesses, the instrument proves to be significantly improved over the previous model. Including so many practitioners from the field and professionals from several universities in the revision process can be credited with the successful improvement of the ADI.

The problem of reliability in factor analysis is always an issue. Like any other statistical procedure, a factor analysis starts with a set of imperfect data. When the data change because of changes in the sample, the data gathering process, or the many kinds of measurement errors, the results of the analysis will change also. Therefore, the results of any single analysis are not entirely dependable. If the result of this study has been to encourage further research and analysis of the Administrative Diagnostic Inventory, an important purpose is realized. As the leadership construct constantly evolves, regular and ongoing validity studies are crucial and necessary.

References

Brubaker, L. (1982). The assessment center method: Developing employees of mid-mangement positions. Journal of College and University Personnel Association, 34, 10-36.

Coleman, D.G. (1973). Improving confirmatory factor loadings through use of symbolic-logic matrices. Unpublished manuscript, Kirksville, MO: Northeast Missouri State University.

Coleman, D.G. (1995). Construct validity: Administrative Diagnostic Inventory for the National Association of Elementary School Principals. Unpublished manuscript, California State University Fresno.

Coleman, D.G. and Creighton, T.B. (1996). Testing confirmatory factoring procedures. Paper presented at the National Council of Professors of Educational Administration 50th Anniversity Conference, Corpus Christi, TX.

Comrey, A.L. (1973). A first course in factor analysis. Los Angeles, CA: Academic Press.

Creighton, T.B. (1996). A construct validation of the Administrative Diagnostic Inventory. Unpublished doctoral dissertation, University of California Davis/California State University Fresno.

Durden, P.C. (1994). A predictive validity study of an administrator assessment system for principal selection and professional development. Unpublished doctoral dissertation, University of Washington.

Edmonds, R. (1982). Program of school improvement: A 1982 overview (ERIC No. ED 221 536). Arlie House, VA: The National Institute of Education.

Elsaesser, L.A. (1990). The relationship between assessment center participation and subsequent staff development activities in practicing and aspiring principals. Unpublished doctoral dissertation, University of Washington.

Glassman, N. and Heck, R. (1992). The changing role of the principal: Implications for principal assessment. Peabody Journal of Education, 68 (3), 2-30.

Gorsuch, R.L. (1983). Factor analysis. Hillsdale, NJ: Lawrence Erlbaum.

Guilford, J.P. (1946). New standards for test evaluation. Educational and Psychological Measurement, 6, 427-439.

Hair, J.F. , Anderson, R.E., and Tathum, R.L. (1979). Multivariate data analysis with readings. Tulsa: Petroleum Publishing Company.

Hallinger, P. (1992). Changing norms of principal leadership in the United States. Journal of Educational Administration, 30 (3), 35-48.

Leithwood, K. and Hallinger, P. (1993). Cognitive perspectives on educational administration: An introduction. Educational Administration Quarterly, 24 (3), 296-301.

Lipman, J.A. (1981). Effective principal, effective school. NASSP Bulletin, 48 (2), 67-84.

Nunnally, J.C. (1978). Psychometric theory. New York: McGraw-Hill.

Sirotnik, K.A. and Durden, P.C. (1996). The validity of administrator performance assessment systems: The ADI as a case in point. Educational Administration Quarterly, 32 (4), 539-564.

Smith, W.F. and Andrews, R.L. (1989). Instructional leadership: How principals make a difference. Alexandria, VA: Association for Supervision and Curriculum Development.

Thompson, B. (1997). The importance of structure coefficients in structural equation modeling confirmatory factor analysis. Educational and Psychological Measurement, 57 (1), 5-19.